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TITLE: Medical fluid injector

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In the specific disclosed embodiment, the air detector generates a light beam and directs this light beam into the tip of the syringe, where it is reflected from the inner wall of the syringe tip and returned into a detector. Other methods of air detection, such as ultrasonic air detection, may also be performed by a detector mounted at the syringe tip with similar advantage, and are encompassed within the scope of the invention.

Another aspect of this feature of the injector is the structure of the syringe tip, which includes an outwardly-projecting transparent section positioned for mechanical coupling to the source of light in the air detector, to facilitate light coupling into the syringe tip for reflection from the inner wall of the tip and return to the detector. This outwardly-projecting section forms a lens for focusing light impinging upon the syringe tip so that this light properly reflects through the interior of the syringe tip.

Referring now to FIGS. 3 and 4, when power head 22 is assembled as shown in FIG. 4, flag washer 82 is positioned opposite to flag sensor 58 on circuit board 55. Flag sensor 58 produces a light beam which, when flag surface 84 is opposite to sensor 58, will be reflected and detected by sensor 58. Cam lever

78 and flag washer 82 are keyed into shaft 79 so that flag surface 84 is rotated opposite to detector 58 only when cam lever 78 is positioned as shown in FIG. 4, in which position cam lever 78 will have translated cam face plate 28 into engagement with the front face 70 of drive housing 69, permitting injection. Thus, when flag surface 84 is opposite to flag sensor 58, this indicates that the face plate is in the closed position, ready for filling or injection.

FIGS. 9 and 10 show illustrative ray traces showing the paths taken by light rays emitted from light source 126. Light source 126 includes an integral focusing lens, and collar 124a on the discharge neck of syringe 36 forms a second focussing lens. These lenses act in concert to direct light from light source 126 along path 129 toward collar 124b on the discharge neck of syringe 36. The internal shape of collar 124b forms a corner reflector, so that light impinging upon collar 124b from light source 126 is reflected toward light sensor 127.

As a result of this structure, when the neck of syringe 36 is filled with fluid, light rays emitted from light source 126 follow paths through the neck of syringe 36, which reflect and return to light sensor 127, such as path 129 illustrated in FIGS. 9 and 10. Accordingly, under such conditions, sensor 127 will produce a digital signal indicating receipt of light, which indicates the absence of air in the syringe neck. (The combined focal length of the lens in light source 126 and collar 124a, is longer than the distance travelled by light along path 129, i.e., longer than twice the distance between collar 124a and collar 124b.)

However, when the neck of the syringe contains air or an air bubble, diffraction of light at air/fluid or air/syringe boundaries will cause light to deviate substantially from the path 129 illustrated in FIGS. 9 and 10. Specifically, light rays incident in the neck of syringe 36 might follow the path 130 illustrated in FIG. 9, or the path 131 illustrated in FIG. 10. In either circumstance, the presence of the air bubble prevents light from

reflecting through the neck of the syringe from light source 126 to light detector 127, thus causing the light detector to produce a signal indicating failure to receive light, indicating that air is present in the neck of the syringe.

a control circuit connected to said motor and said display, controlling said motor to move said ram and plunger to inject fluid from said syringe, and generating display information and delivering said display information to said display,